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Apparatus and Procedure for Sampling Soil Profiles for Volatile Organic Compounds

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APPARATUS AND PROCEDURE FOR SAMPLING SOIL PROFILES FOR VOLATILE ORGANIC COMPOUNDS[1]

A. L. Wood, J. T. Wilson, R. L. Cosby, A. G. Hornsby, and L. B. Baskin[2]

Abstract

A conventional soil-solution sampler was modified to prevent loss of volatiles, which tend to escape from the liquid sample during sample collection. The sampler is connected to a purging chamber, which is in turn connected to a trap packed with Tenax resin. The sample is collected by applying a vacuum to the downstream end of the trap. Material that volatilizes during collection of the aqueous sample is captured on the trap. Material that remains in the aqueous sample is purged from solution with N_2 and captured on the same trap. The trap is then returned to the laboratory for desorption and determination of the individual pollutants by conventional methods for volatile organic analysis.

Additional Index Words: trichloroethene, trichloroethylene, soil leaching, water pollution.

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[1] Contribution from the Robert S. Kerr Environmental Research Laboratory, USEPA, Ada, OK 74820. Received 8 Aug. 1980. Approved 5 Dec. 1980.

[2] Soil Scientist, Microbiologist, Chemist, Soil Scientist, and Agricultural Engineer, respectively, USEPA, P.O. Box 1198, Ada, OK 74820.

INVESTIGATIONS PERTAINING to the pollution of ground water often require the analysis of organic compounds in water percolating through soil profiles. Sampling of such water in shallow (< 9 m) profiles is usually achieved by means of suction probes or soil-solution samplers, which consist of porous ceramic cups installed at desired depths within the soil profile and subjected to vacuum for sample acquisition (USEPA, 1975).

If volatile compounds are present in the sampled water, however, significant and unknown quantities of these compounds may be lost by vaporization during collection. Hence, the samples obtained are not suitable for analysis of a number of toxic organic pollutants, such as trichloroethene, 1,1,2-trichloroethane, tetrachloroethene, and 1,2-dibromo-3-chloropropane, which are of particular concern to the U.S. Environmental Protection Agency because of the high frequency with which they are reported in cases of ground-water pollution. For this reason, an in situ sampling procedure that permits quantitative analysis of most volatile organic pollutants in water percolating through the soil profile has been developed at this laboratory. This procedure should be generally applicable for analysis of soil solution for volatile organic constituents.

Sampling Procedure

The procedure employs a sample collection system constructed by appropriately modifying components used in the standard purge-and-trap method for volatile organic pollutants in water and wastewater (U.S. Environmental Protection Agency, 1979; Bellar and Lichtenberg, 1974, 1978) and coupling these modified components with the traditional soil-solution sampler. This system, depicted in Fig. 1, consists of five principal units: (i) a soil-solution sampler, (ii) a purging apparatus, (iii) a trap for volatile organic compounds, (iv) a vacuum source, and (v) a source of high-purity inert purge gas. The soil-solution sampler is constructed from a porous ceramic cup (2.2 cm o.d., wall thickness 0.24 cm, neck diam 1.4 cm) with an air-entry of 1 bar (catalogue no. 2131, Soilmoisture Equipment Co., Santa Barbara, Calif.), schedule 80 PVC pipe, and a silicone rubber stopper, size 00. The purging apparatus is assembled using a 10-ml glass-frit sampler from a Tekmar Liquid Sample Concentrator (Model LSC-1, Tekmar Corp., Cincinnati, Ohio), "Elast-o-Fluor" Teflon plug valves (catalogue no. 6392, Horizon Ecology Co., Chicago, Ill.), and Teflon tubing connectors. The traps are constructed from glass-lined stainless steel tubing (5.2 mm o.d., 2.0 mm i.d., 28 cm long) packed with 60/80 mesh Tenax GC resin and plugged with glass wool. The vacuum source is a Masterflax portable sampler (catalogue no. 7570, Horizon Ecology Co., Chicago, Ill.) powered by a 12-V battery. Purge gas is supplied by a cylinder of high-purity N_2. All tubing contacting the sample is Teflon with Teflon connectors.

After installation of the soil-solution sampler at the proper depth in the soil profile, the sequence for sampling is as follows:

1) With the exhaust tube open to the atmosphere and the collection tube disconnected from the purging apparatus, a vacuum is applied to the collection tube and all liquid and vapor is removed from the soil-solution sampler and discarded.

2) With the exhaust tube closed, the collection tube connected to the purging apparatus, valves "A" and "B" open, and valve "C" closed, a vacuum is applied to the downstream end of the trap.

3) After sufficient liquid is drawn into the purging apparatus, valve "A" is closed, the vacuum supply to the trap is disconnected, valve "C" is opened, and the volatile organic compounds are purged from the liquid sample into the trap with N_2 (40 ml/min for 15 min).

4) The trap is removed from the sampling system, tightly capped, and returned to the laboratory, where the volatile compounds retained in the trap are desorbed directly into a gas chromatography column for separation and quantitation in accordance with accepted methods for volatile organic analysis (USEPA, 1979). Desorption is achieved by heating and backflushing the trap in a Tekmar LSC-1 Liquid Sample Concentrator. If the trap cannot be processed within 12 hours of sample acquisition, it is stored in a freezer. Standards are determined by purging solutions of known concentration, under conditions similar to those encountered in the field.

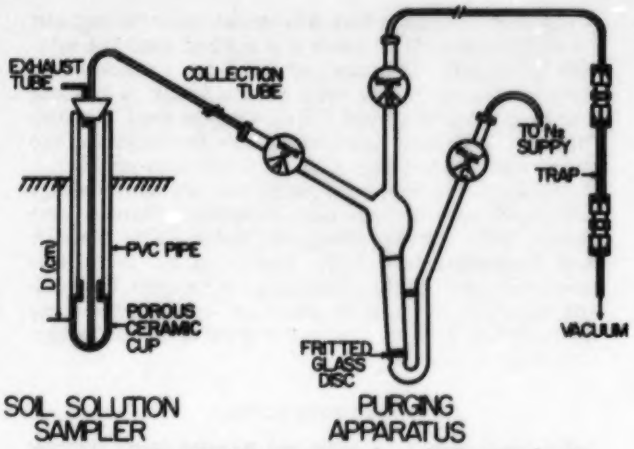

Fig. 1—Sample collection apparatus for volatile organic compounds in soil solution.

Field Evaluation

The technique was used to monitor the transport of trichloroethene (TCE) through an in situ soil profile. The efficiency of the purger and trap for recovery of TCE was determined by analysis of replicate 25-ml samples of deionized water containing 2.5 μl of TCE. The average recovery was 103 ± 9.8% ($\alpha = 0.05$).

A 3- by 3-m plot of Konawa sand (fine loamy, mixed, thermic Ultic Haplustalfs) was flooded until a constant hydraulic flux of 0.4 cm/hour was attained. Then the floodwater was replaced with a solution containing 750 μg/liter TCE plus 300 mg/liter Cl^- added as a tracer for the water. The volume of solution that infiltrated was equal to approximately 20% of the pore water volume of the soil to a depth of 150 cm.

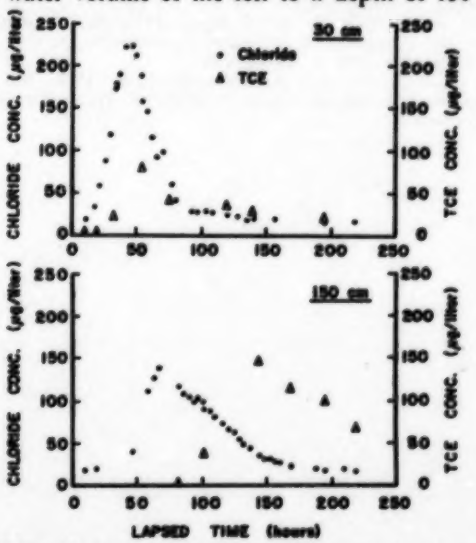

Fig. 2—Distribution of chloride and TCE with time at the 30 and 150-cm depths in Konawa soil.

A constant hydraulic flux was maintained throughout the experiment. Well water was applied after the solution infiltrated. Data are presented for a soil-solution sampler placed 30 cm deep in the sandy A horizon and for a sampler placed 150 cm deep in the C horizon (Fig. 2). The data demonstrate the feasibility of the technique for sampling TCE in the in situ profile.

Although the method is subject to all shortcomings associated with soil-solution samplers (Hansen and Harris, 1975; van der Ploeg and Beese, 1977; Warrick and Amoozegar-Fard, 1977; Shaffer et al., 1979), this procedure can obtain representative samples for analysis of those volatile organics in water percolating through soil profiles that are amenable to the purge-and trap method.

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